

Figure 1. Annual average change in temperature, 1895-2006 (°F)

Figure 2. Average annual temperature change -- winter, 1895-2006 (°F)

Minnesota Pollution Control Agency. (2010). *Adapting to Climate Change in Minnesota: Preliminary Report of the Interagency Climate Adaptation Team*, p. 4-5. Retrieved from www.pca.state.mn.us/index.php/download-document.html?gid=15414

TRUE STATEMENTS

Temperature in Minnesota has increased an average of 1.8 degrees since 1895.

Temperature in the winters has increased almost twice as much as the average increase since 1895.

Minnesota has shown the highest increase in temperatures across the Midwest.

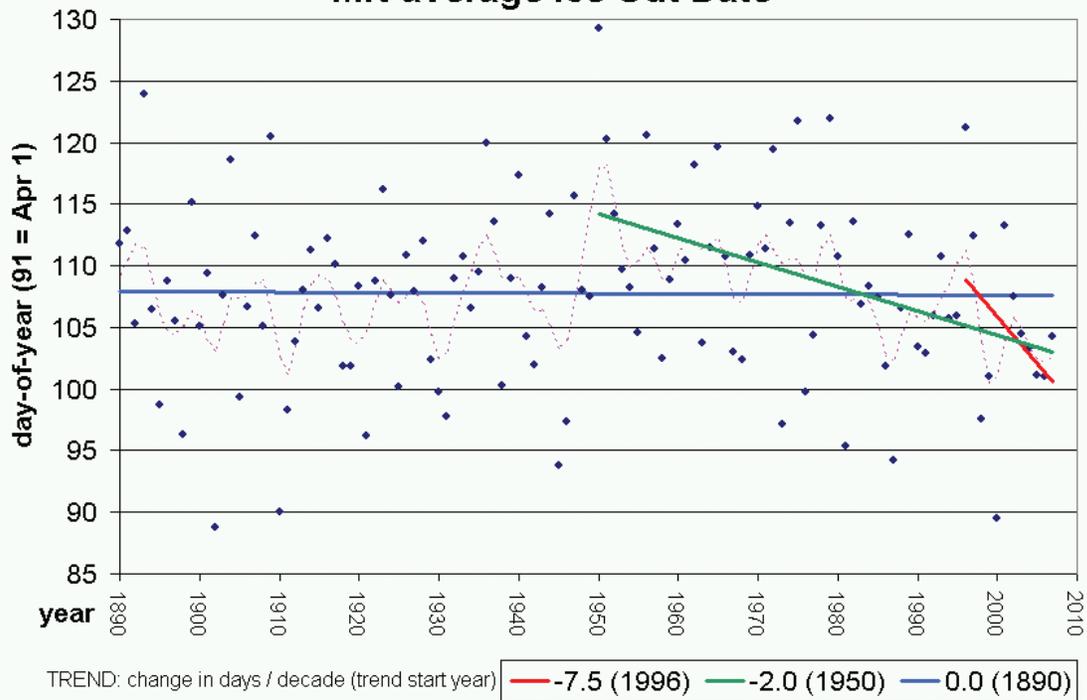
FALSE STATEMENTS

Minnesota winters have gotten colder since 1895.

The highest increase in temperatures since 1895 has been seen in the summers.

Minnesota has seen colder temperatures 3.1 times since 1895.

MN average Ice Out Date



State Climatology Office, DNR Waters, 2008

Ice out, like snow, is one of the many results of both temperature changes and humidity changes since both represent heat changes. Lake ice out has been getting earlier in the last few decades. The rate at which it has been getting earlier is greater in recent record than for longer periods.

Zandlo, Jim. (last modified 2008) *Climate Change and the Minnesota State Climatology Office: Observing the Climate*. Retrieved from <http://climate.umn.edu/climateChange/climateChangeObservedNu.htm>

TRUE STATEMENTS

The earliest day the ice was recorded to go out was in the early 1900's.

The red, green and blue line are comparing how rate at which the ice has been going out earlier has changed and that rate is greater more recently.

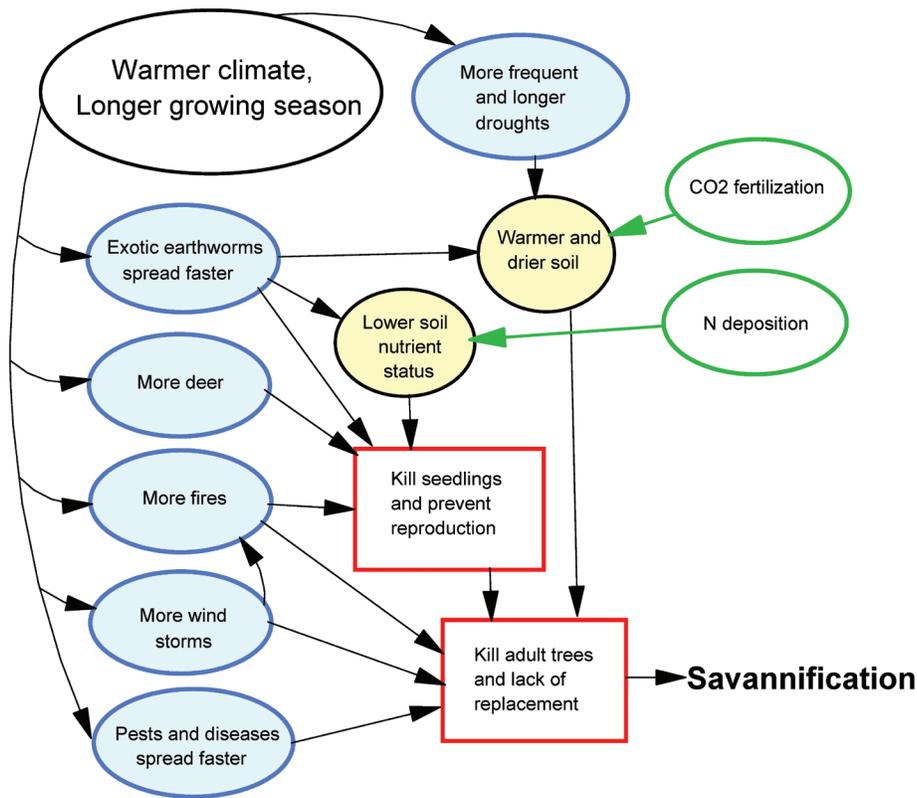
The latest day the ice was recorded to go was in 1950.

FALSE STATEMENTS

On the y-axis, 91 is the same as May 1.

The dots on the graph represent the days when the first lake froze in Minnesota, in that year.

This graph shows that lakes are staying frozen longer than they used to.



Interactions between global warming and other drivers of change affecting the prairie-forest border of central North America, and other impact on trees. Blue ovals represent drivers with potential negative impacts on trees that are likely to be enhanced by a warmer climate. Yellow ovals represent basic resources that may be changed by a warmer climate or by its interactions with other drivers. Green ovals represent drivers that may counteract negative impacts on trees to some extent. Red rectangles show the results of drivers on trees and their reproduction.

Frehlich LE and Reich PB. 2009. Will environmental changes reinforce the impact of global warming on the prairie-forest border of central North America? *Frontiers In Ecology*.

TRUE STATEMENTS

Although a warmer climate might cause longer and more frequent droughts, carbon dioxide fertilization might help plants survive.

Pests and disease may be a cause of a more make the forest on the prairie-forest border more savanna-like.

A warmer climate could lead to an increase in deer populations.

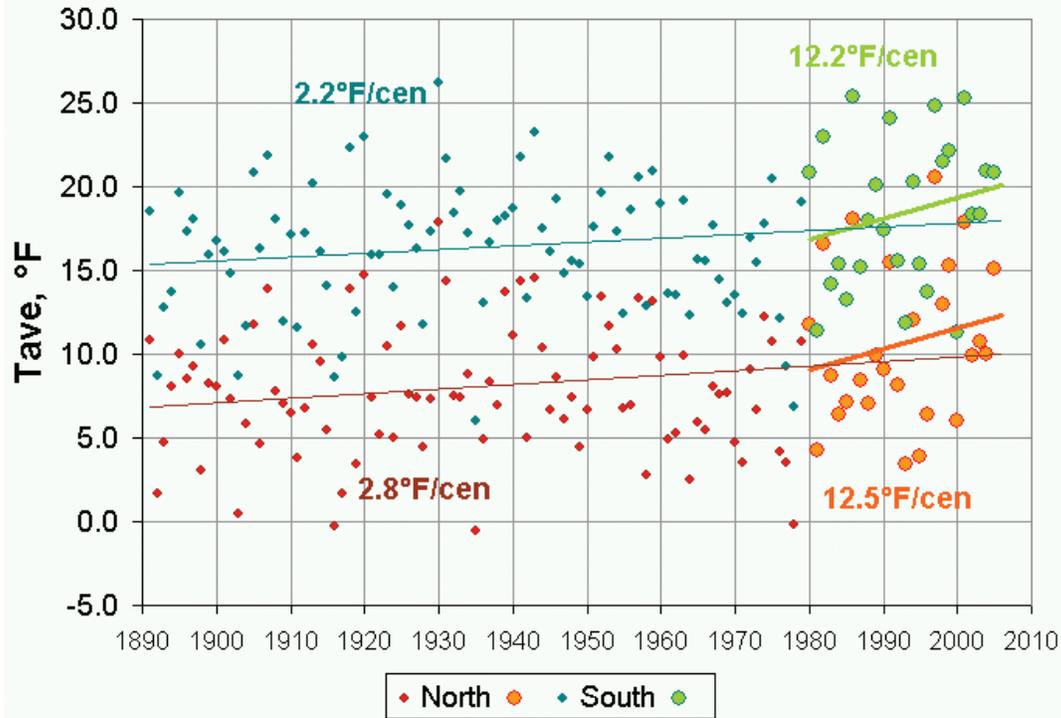
FALSE STATEMENTS

Earthworms will help fight the impacts of a warming climate.

Nitrogen deposition will impact the soil by lowering the soil nutrients.

A warming climate will most likely increase tree density on the prairie-forest border.

Minnesota Multi Division DJF Tave (from grids)



State Climatology Office, DNR Waters, 2008

From the beginning of the record in 1891 to the early 1980's Minnesota's average annual temperature did not change; its trend was essentially zero. Since the early 1980's the temperature has risen slightly over 1 degree F in the south to a little over 2 degrees F in much of the north; the trend has been upward.

Zandlo, Jim. (last modified 2008) *Climate Change and the Minnesota State Climatology Office: Observing the Climate*. Retrieved from <http://climate.umn.edu/climateChange/climateChangeObservedNu.htm>

TRUE STATEMENTS

If the graph ended in 1980 there would be no indication of warming in Minnesota.

The green dots show average annual temperature in the southern portion of Minnesota since 1980.

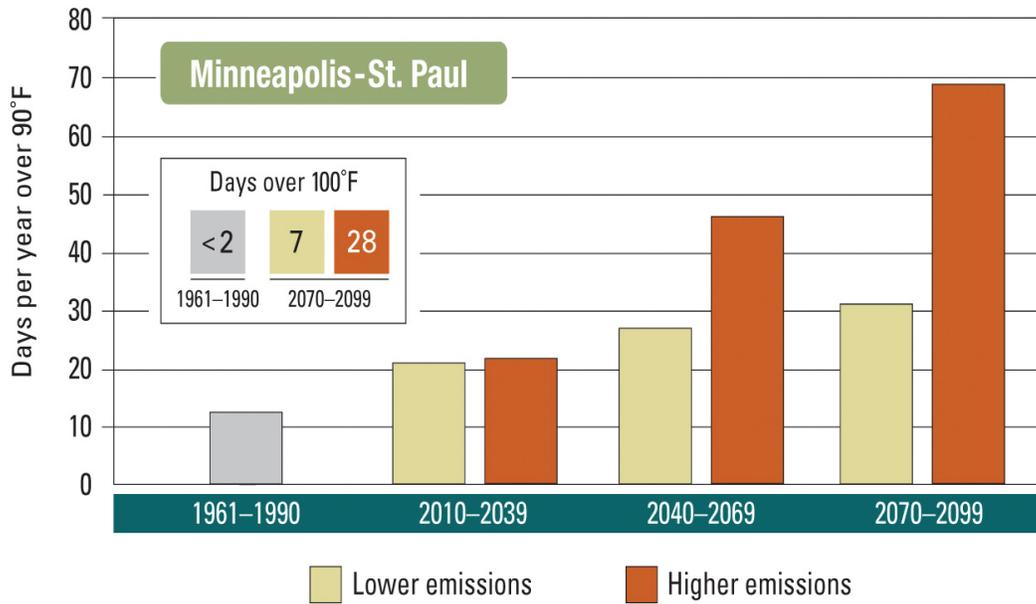
If the warming trend continues in the northern portion of Minnesota there could be as much as a 7.2 degree increase in average temperature by the end of the century.

FALSE STATEMENTS

The lowest average temperature in the southern portion of Minnesota occurred in 1930.

The data representing the southern part of the state are on the bottom and the data representing the northern part of the state are on the top of the graph.

The temperature on the y axis is in Celsius.



Extreme Heat Becomes More Frequent

This figure shows how models predict the temperature of the Twin Cities could change if we continue to emit large quantities of Carbon dioxide (higher emissions scenario), or if we make some changes and cut our emissions (lower emissions scenario).

Union of Concerned Scientists. (2009). *Confronting Climate Change in the US Midwest: Minnesota*. Chicago IL.

TRUE STATEMENTS

Under the higher-emissions scenario the Twin Cities could experience almost an entire summer of days above 90 degrees F by the end of the century.

Between 1960 and 1990 there were less than 2 days over 100 degrees F during the summer in the Twin Cities.

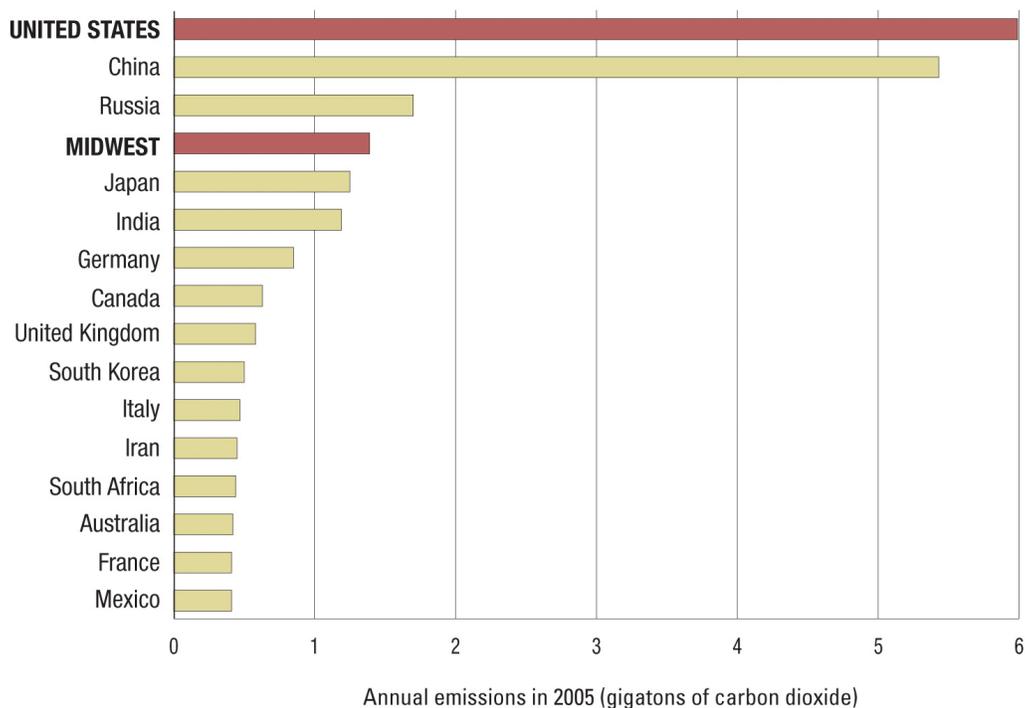
The impacts of higher emissions as compared with lower emissions, will become apparent beginning in 2040.

FALSE STATEMENTS

This bar graph shows how precipitation will change in the Twin Cities.

Under a higher emissions scenario there will be 7 days over 100 degrees F between 2070 and 2099.

This bar graph compares how the temperatures of Minneapolis and St Paul will change under different emission scenarios.



The Midwest Burns More Fossil Fuels Than Entire Nations

Union of Concerned Scientists. (2009). *Confronting Climate Change in the US Midwest: Minnesota*. Chicago IL.

TRUE STATEMENTS

The total combined emissions from the eight Midwest states (Illinois, Indiana, Iowa, Michigan, Missouri, Ohio, and Wisconsin) would make the Midwest the world's fourth largest polluter if it were a nation.

The Midwest's emissions are more than double that of the United Kingdom.

The United States emitted 6 gigatons of carbon dioxide in 2005.

FALSE STATEMENTS

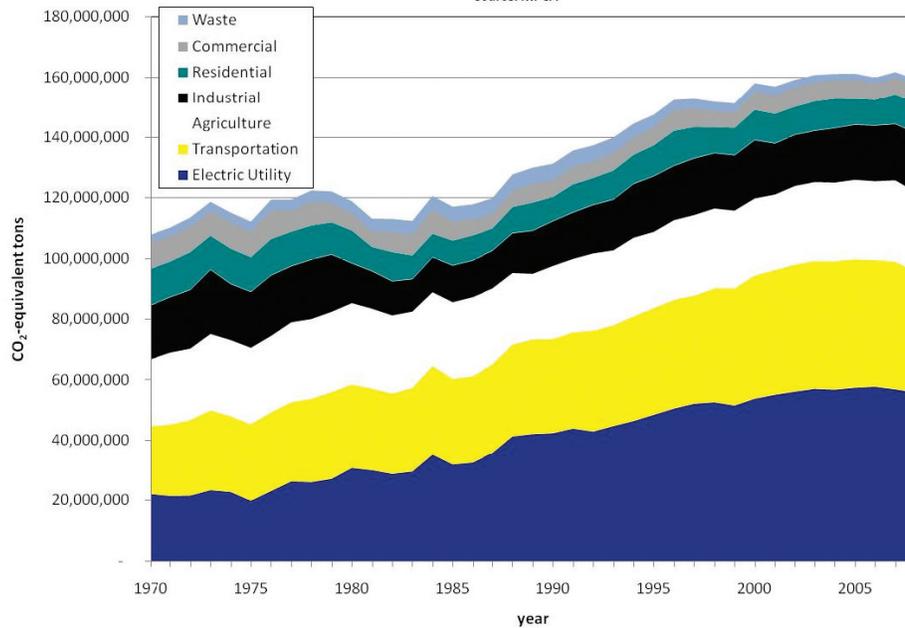
The United States emitted 6 tons of carbon dioxide in 2005.

The Midwest's carbon dioxide emissions are equal to Australia's emissions.

China emitted more carbon dioxide than the United States in 2005.

Figure 2
Greenhouse Gas Emissions from Minnesota by Economic Sector

Source: MPCA



Greenhouse Gas Emissions from Minnesota by Economic Sector

Minnesota Department of Commerce, and Minnesota Pollution Control Agency. (2011) *Annual Legislative Proposal Report on Greenhouse Gas Emission Reductions and Biennial Greenhouse Gas Emissions Report to the Minnesota Legislature Minn. Stat. 216H.07, subd. 3 and 4.*

TRUE STATEMENTS

The long term trend shows increasing greenhouse gas emissions.

The electric power and transportation sector combined account for about 60 percent of emissions from Minnesota.

The waste sector shows a slight decrease in emissions.

FALSE STATEMENTS

The waste sector accounts for the majority of the greenhouse gas emissions from Minnesota.

Electric utilities account for the least amount of emissions from Minnesota.

This graph shows the amount of all greenhouse gas emissions including carbon dioxide, methane, etc. from Minnesota.

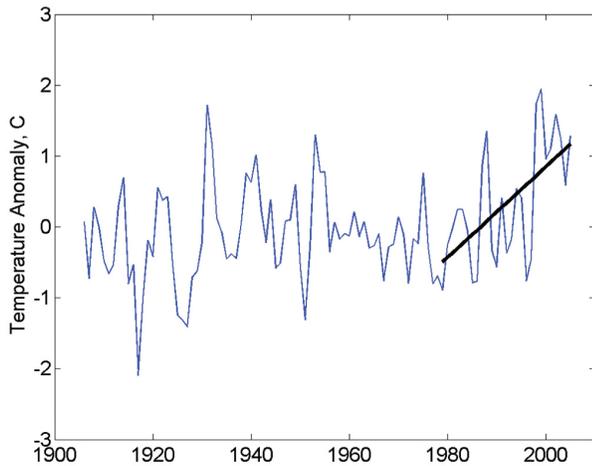


Figure A

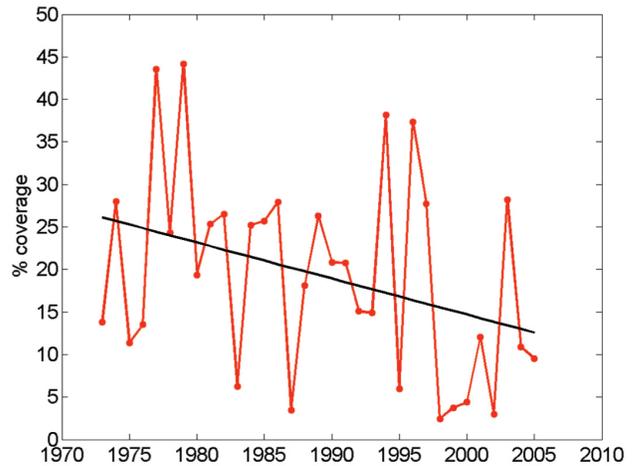


Figure B

Regional air temperature and average ice cover of Lake Superior:

a) mean July-September air temperatures from GISS sites on Lake Superior (available from <http://data.giss.nasa.gov/gistemp/>) and b) ice cover metric [Assel, 2003; 2005b] in percent.

Austin, J.A. and S.M. Colman. 2008. A century of temperature variability in Lake Superior. *Limnol. Oceanogr.* 53, 2724-2730.

TRUE STATEMENTS

Since 1980 mean air temperatures over Lake Superior have risen over 1 degree Celsius.

Since 1980 Lake Superior ice cover has declined almost 10 percent.

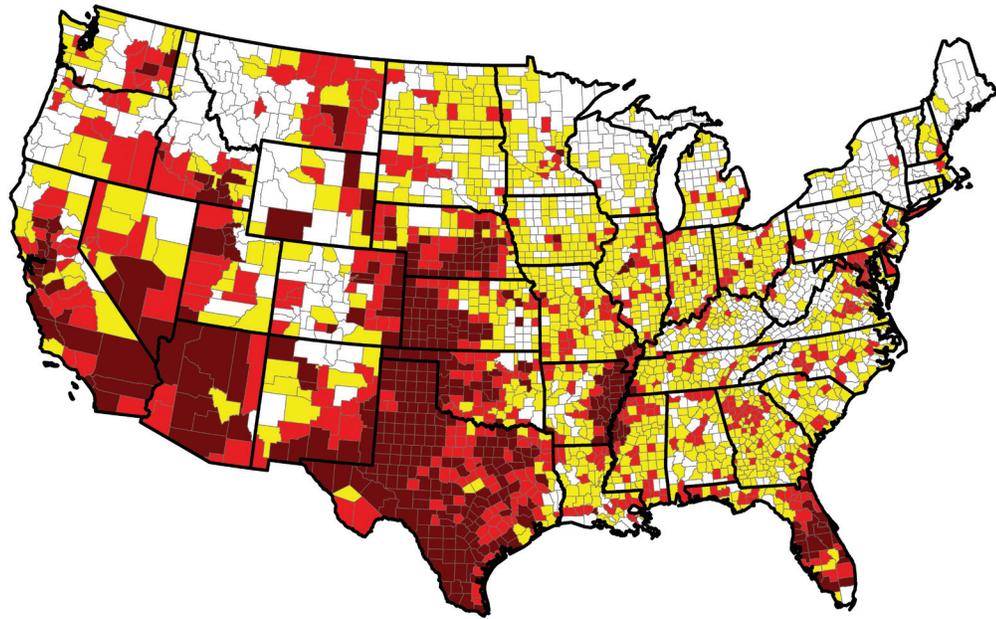
An decrease in ice cover follows an increase in air temperature.

FALSE STATEMENTS

Mean air temperature in 2005 was 15 degrees Fahrenheit.

There is no correlation between ice cover and temperature.

These graphs compare the temperature of Lake Superior in winter and summer.



Water Supply Sustainability Index (2050)

- Extreme (412)
- High (608)
- Moderate (1192)
- Low (897)



Water Sustainability Index in 2050; with available precipitation computed using projected climate change. (The numbers in parentheses are the numbers of counties in each category.)

Natural Resources Defense Council. (2010). *Evaluating Sustainability of Projected Water Demands Under Future Climate Scenarios*. Lafayette, CA: Tetra Tech, Inc.

TRUE STATEMENTS

The risks to sustainability are classified into four categories from Extreme to Low.

The number of counties at an extreme or high risk are almost equal to those at a moderate risk.

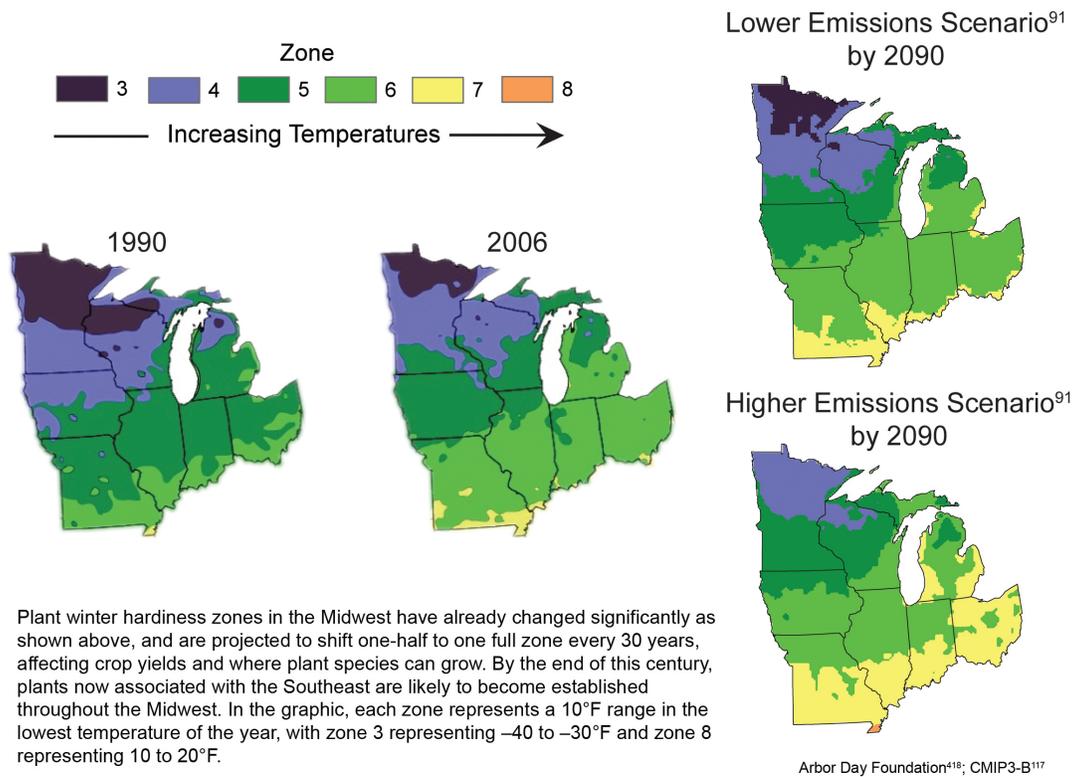
Those at the highest risk in Minnesota are found general in urban areas.

FALSE STATEMENTS

Those at the most risk are found in the Northern parts of the country.

This map shows where water quality may decrease under climate change.

This map shows how temperature will affect water availability.



Observed and Projected Changes in Plant Hardiness Zones

Each zone represents a 10 degree F range in the lowest temperature of the year, with zone 3 representing -40 to -30 degree F and zone 8 representing 10 to 20 degrees F.

U.S. Global Change Research Program. (2009). *Global Climate Change Impacts in the United States*. New York, NY: Cambridge University Press.

TRUE STATEMENTS

Between 1990 and 2006 a change in plant winter hardiness zones can be seen.

By the end of this century plants now associate with the Southeast are likely to become established throughout the Midwest.

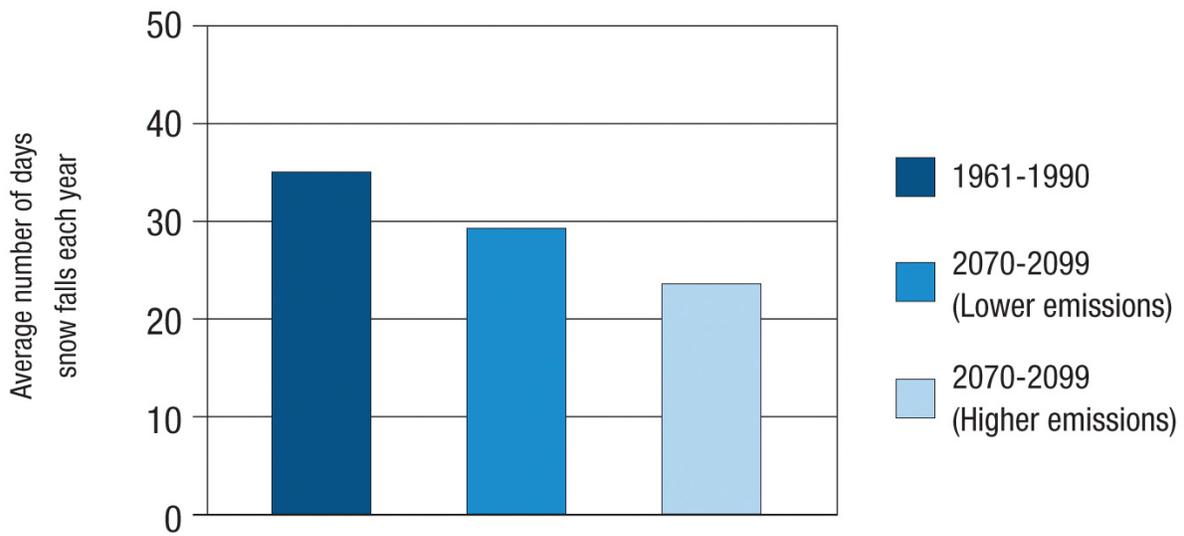
Winter hardiness zones are projected to shift one-half to one full zone every 30 years.

FALSE STATEMENTS

These maps show where what types of crops we should plan on planting in 2090.

By 2090 Most of Minnesota will be Zone 6.

Minnesota will see little change in plant zones under these projections.



Fewer Days of Snow Falling

Union of Concerned Scientists. (2009). *Confronting Climate Change in the US Midwest: Minnesota*. Chicago IL.

TRUE STATEMENTS

Minnesota winters may become shorter as the climate warms.

Under higher emission scenarios, Minnesota will have a third fewer days every year when snow falls than they did historically.

Even if emissions decrease, Minnesota is predicted to have shorter winters.

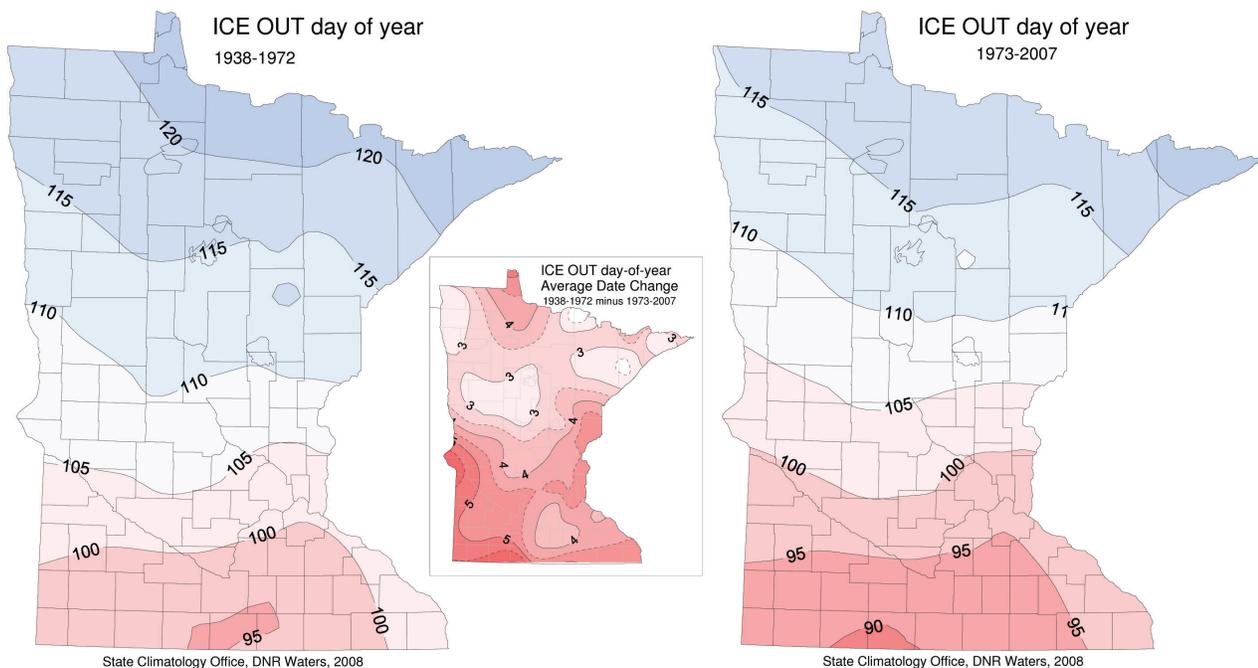
FALSE STATEMENTS

This graph shows that predictions show precipitation in Minnesota will be less with an increase in greenhouse gas emissions.

If Minnesota has lower emissions in the future there will likely not be a change in the length of winter.

This graph shows that historically Minnesota has an average of 25 days of snow fall per year.

Ice out dates in Minnesota 'in your father's time' were generally later than they have been in recent decades. The ice out pattern for the most recent 35-year period is shown along with the pattern for the 35-year period before that time. The small map between the maps of the 2 periods shows the number of days that ice out has become earlier. (Note: day 90 is Mar 31, 120 is Apr 30)



A comparison of ice out dates in Minnesota between 1938-1972 and 1973-2007.

(Note: Day 90 is March 31, 120 is April 30)

Zandlo, Jim. (last modified 2008) *Climate Change and the Minnesota State Climatology Office: Observing the Climate.* Retrieved from <http://climate.umn.edu/climateChange/climateChangeObservedNu.htm>

TRUE STATEMENTS

Ice out dates between 1938-1972 were generally later than they were 1973-2007.

The small map shows the number of days that ice out has become earlier.

Ice out in the Southwest corner of the state has been about 5 days earlier in recent decades.

FALSE STATEMENTS

The Northern part of the state has seen 115 days of ice in recent decades.

These maps compare lake water levels in Minnesota.

These maps show current and projected ice out dates for Minnesota.